

## **REGOLITH MATERIALS**

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# **Regolith Materials**

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# Goals

- **In-Situ Resource Utilization**
  - using regolith
- **In-Space Manufacturing**
  - fabricating materials
- **Radiation Protection Methods**
  - developing habitat concepts
- **Radiation Physics**
  - measuring radiation transmission

# Problem

## Martian Environment

- Low-intensity energetic heavy-ion flux of Galactic Cosmic Radiation (GCR)
- Solar Particle Events (SPE)
- Neutron radiation
- Global dust storms (wind speed = 17-30 m/sec)

## Mars Exploration Fact

- Earth return possible at specified times (~ every 26 months)

⇒ Need habitat to provide safe haven for human explorers

## Martian Regolith (Viking Lander Data)

- Average Density  
1.4 g/cm<sup>3</sup>
- Chemical Composition  
58.2% SiO<sub>2</sub>  
23.7% Fe<sub>2</sub>O<sub>3</sub>  
10.8% MgO  
7.3% CaO

Predicted Annual Dose Equivalent  
Behind Martian Rocks and Martian Regolith  
(cSv/yr)

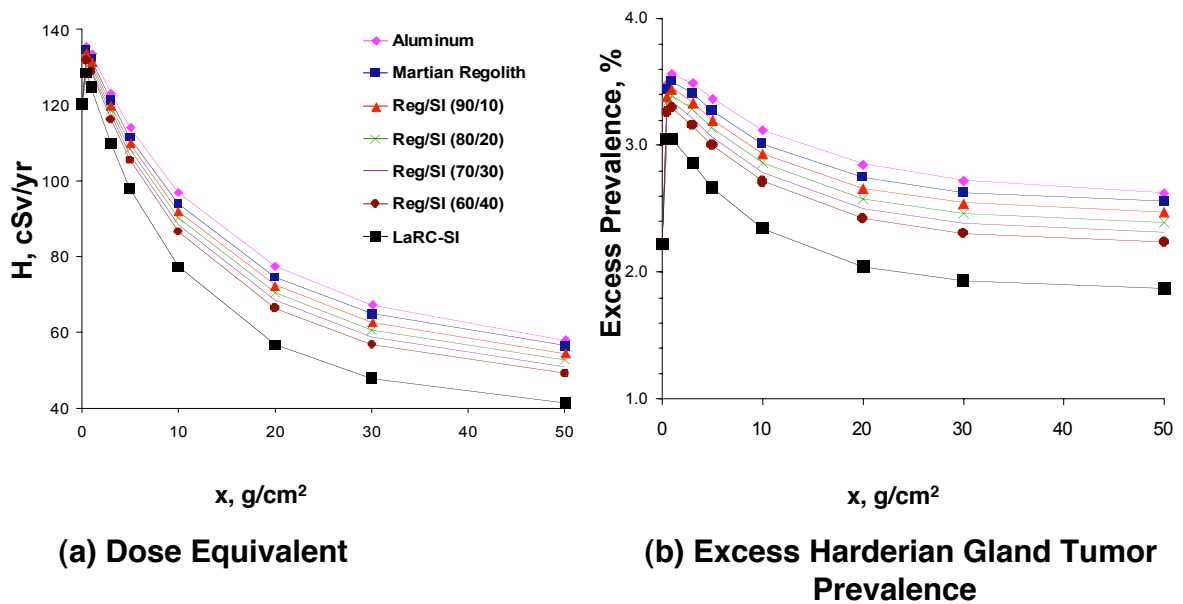
Thickness g/cm <sup>2</sup>	Basalt	Lherzolite	Clino- pyroxenite	Ortho- pyroxenite	Dunite	Martian Regolith
1	132.3	132.3	132.4	132.2	132.4	<b>132.3</b>
5	111.5	111.4	111.8	111.1	111.8	<b>111.5</b>
10	94.0	93.8	94.3	93.4	94.3	<b>93.9</b>
30	64.8	64.6	65.2	64.2	65.2	<b>64.8</b>
50	56.5	56.2	56.8	55.9	56.8	<b>56.5</b>

## Predicted Biological Responses Behind Martian Regolith and Aluminum After 1-Year GCR Exposure

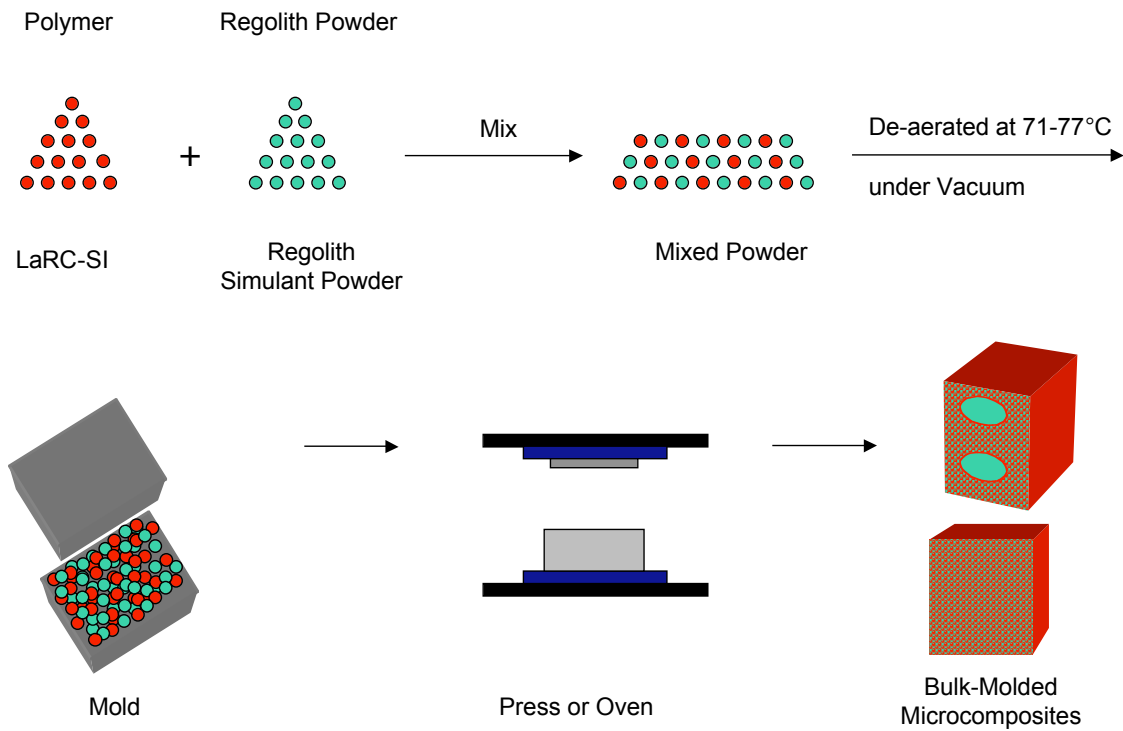
Thickness g/cm <sup>2</sup>	C3H10T1/2 Cell Death Rate, %	C3H10T1/2 Cell Transformation Rate, x 10 <sup>-3</sup> %	Excess Harderian Gland Tumor Prevalence, %
<b>Martian regolith</b>			
1	3.92	1.74	3.50
5	3.28	1.65	3.28
10	2.74	1.54	3.02
30	1.89	1.34	2.63
50	1.65	1.29	2.56
<b>Aluminum</b>			
1	3.94	1.76	3.57
5	3.33	1.70	3.37
10	2.80	1.59	3.12
30	1.91	1.39	2.73
50	1.65	1.33	2.63



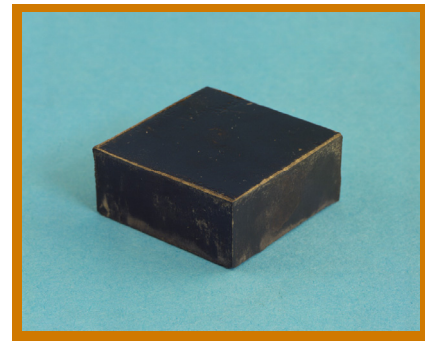
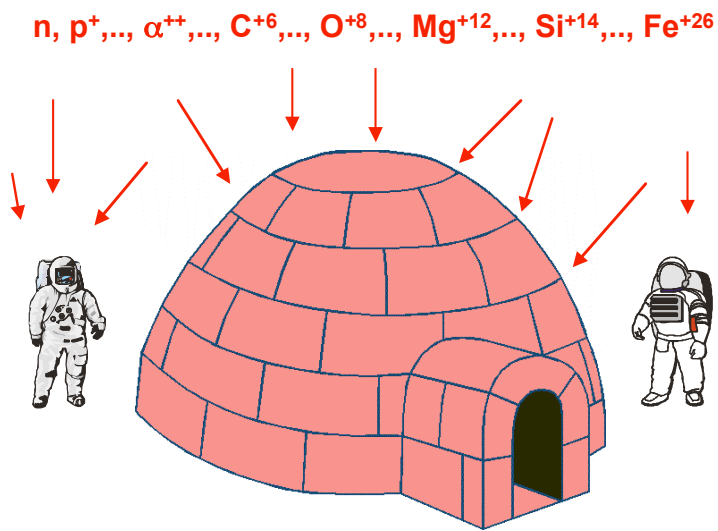
## Predicted Biological Responses Behind Various Materials After 1-Year GCR Exposure



## Fabrication of Shielding and Habitat Components for Ground Tests



## Habitat Construction/Radiation Shielding for Martian Exploration and Development



Regolith/LaRC-SI  
(80%/20% by weight)  
microcomposite block

## **Microwave Oven**

Manufacturer: Panasonic

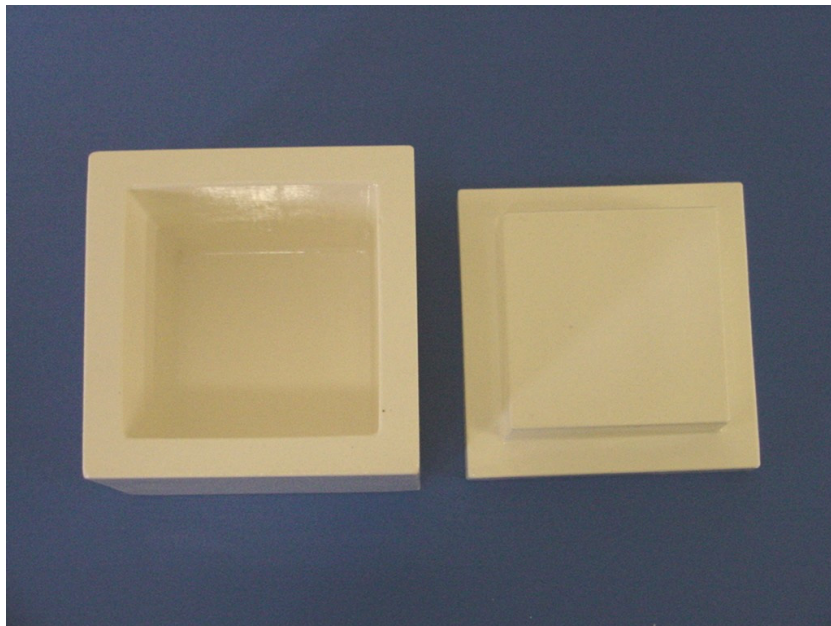
Model #: NN-S950

Oven size: 14" x 23 7/8" x 19 1/2" (h x w x d)

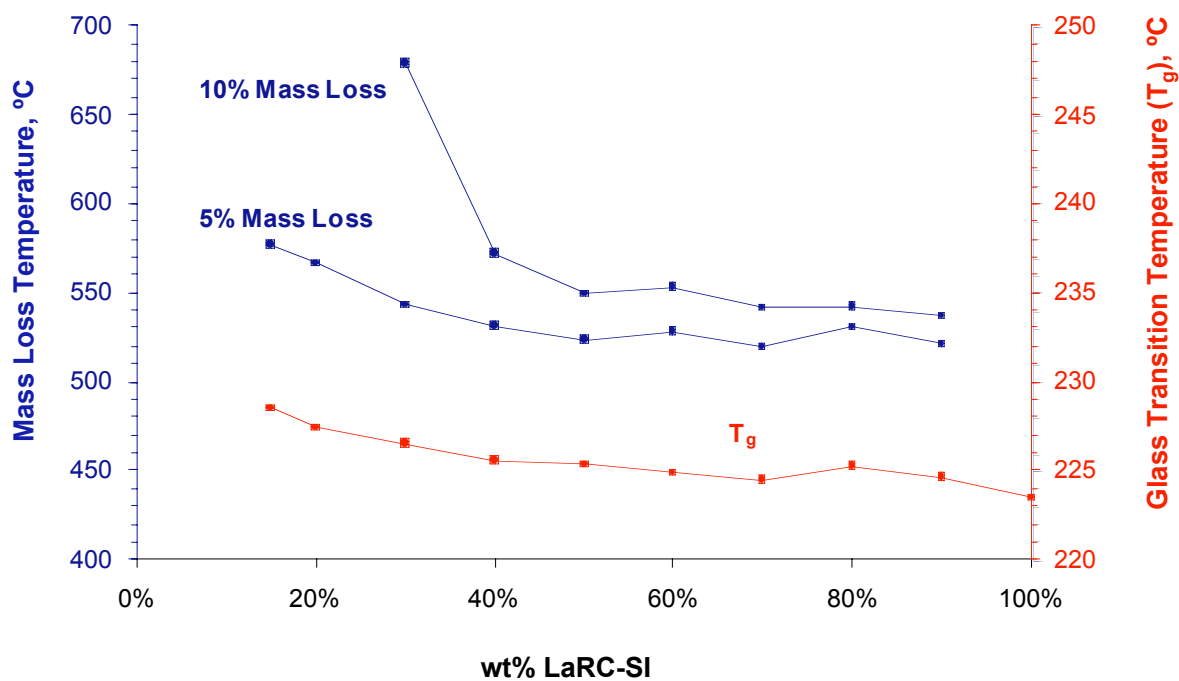
Cavity size: 11" x 18 1/2" x 18 1/2" (h x w x d)

Output: 1300 W at 2.45 GHz

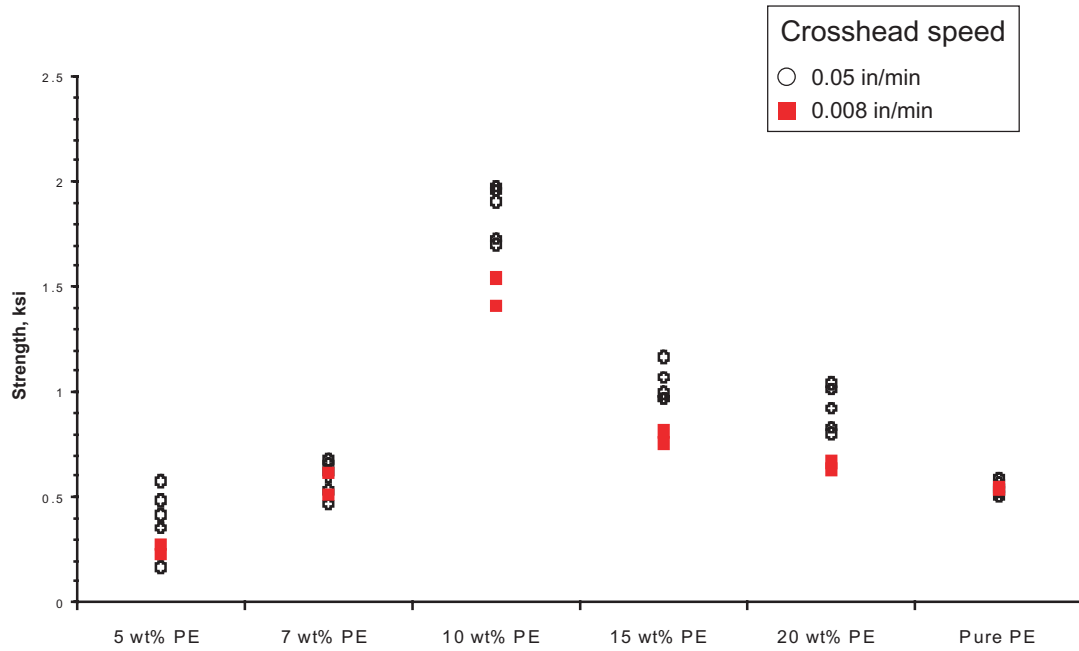
## Ceramic Mold for Microwave Processing



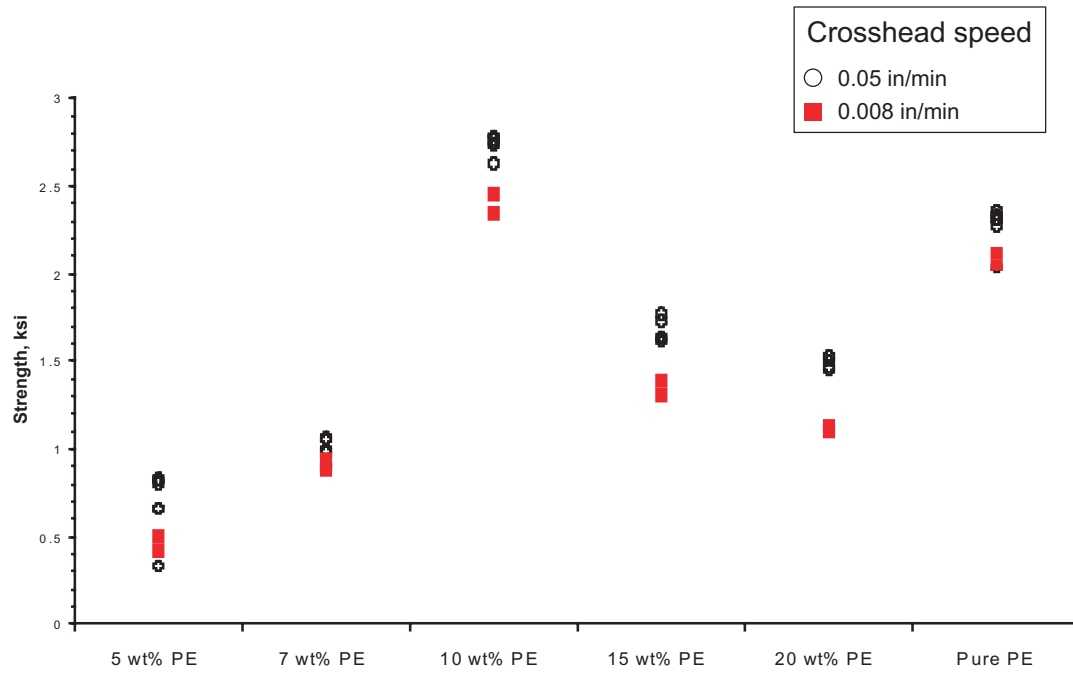
## TGA Mass Loss and TMA Glass Transition Temperatures for Regolith/LaRC-SI Microcomposites



## Compressive Yield Strength for Regolith/PE Microcomposites

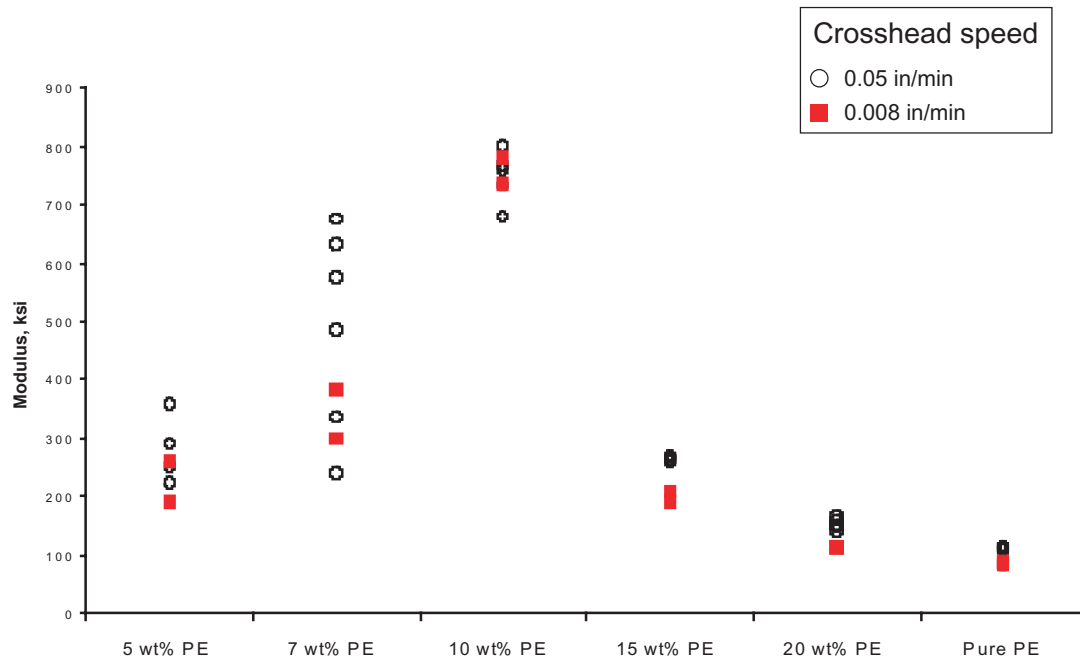


## Ultimate Compressive Strength for Regolith/PE Microcomposites

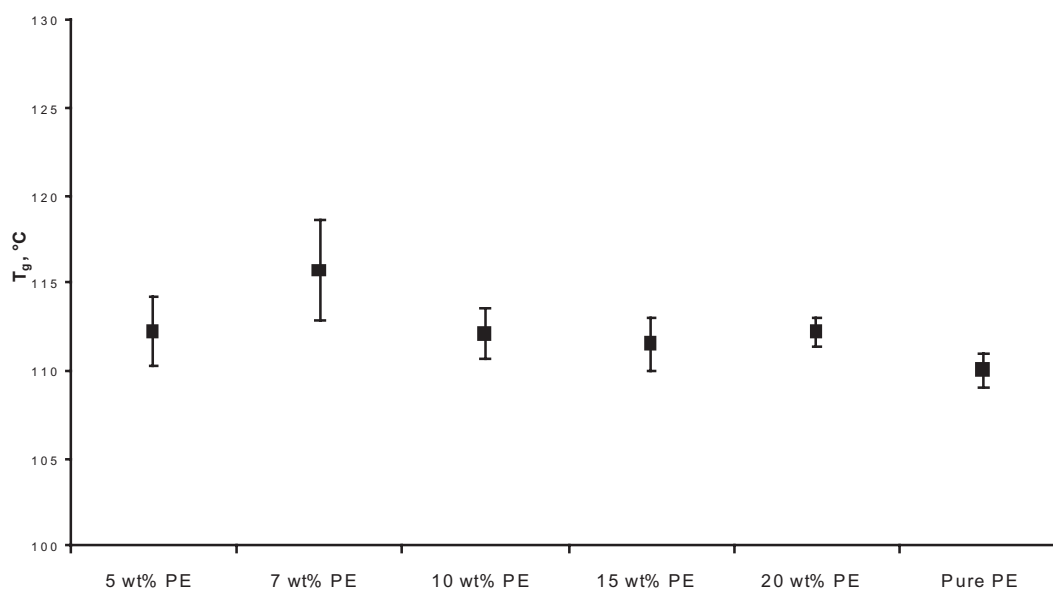




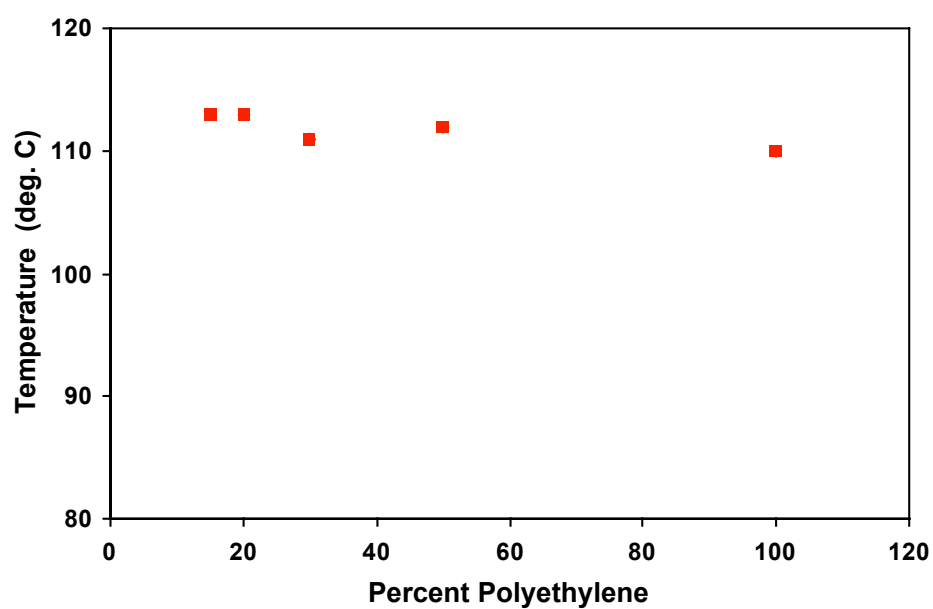
## Compressive Modulus for Regolith/PE Microcomposites



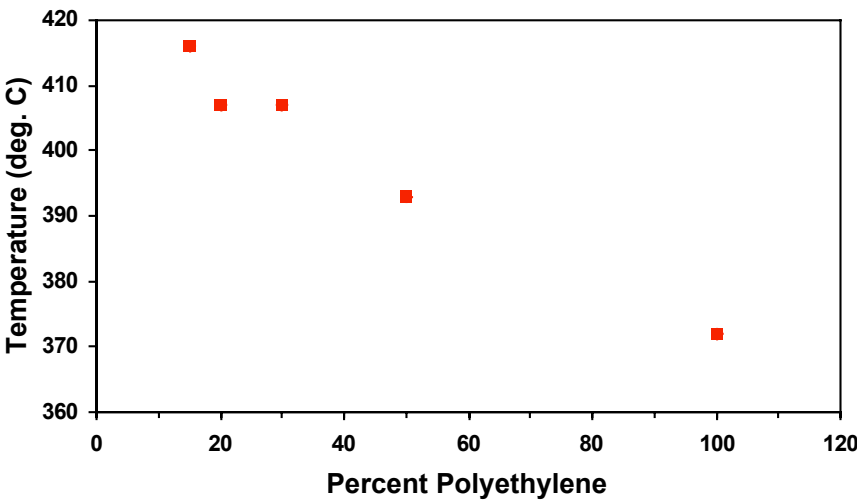
## TMA Glass Transition Temperature for Regolith/PE Microcomposites



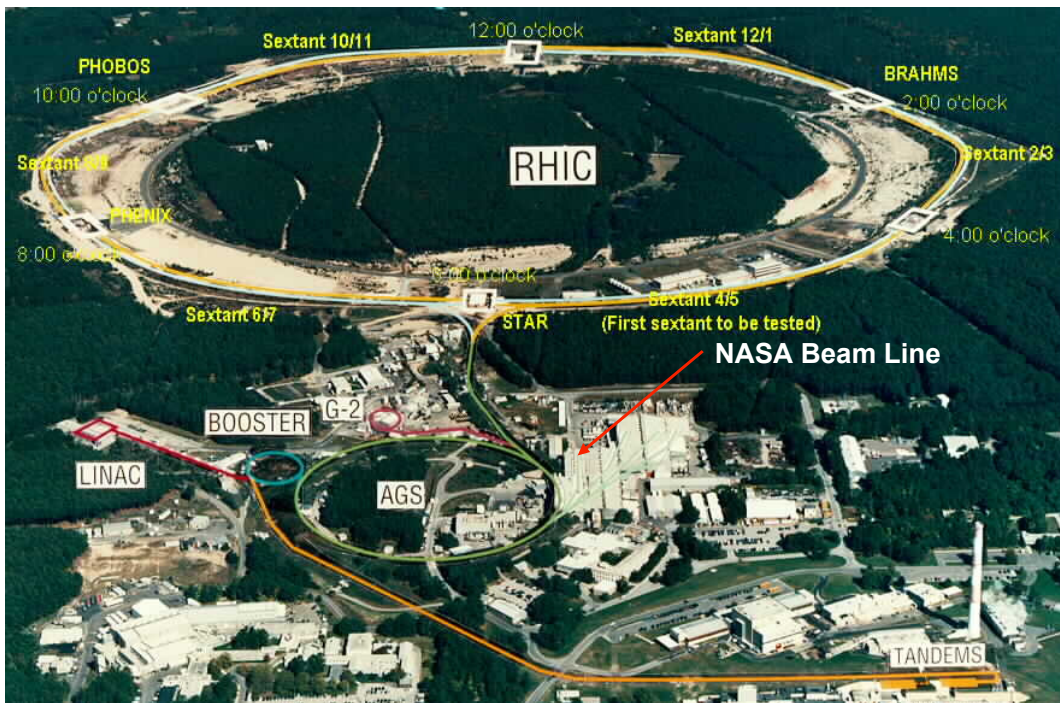
TMA Softening Temperature  
for Regolith/PE Microcomposites



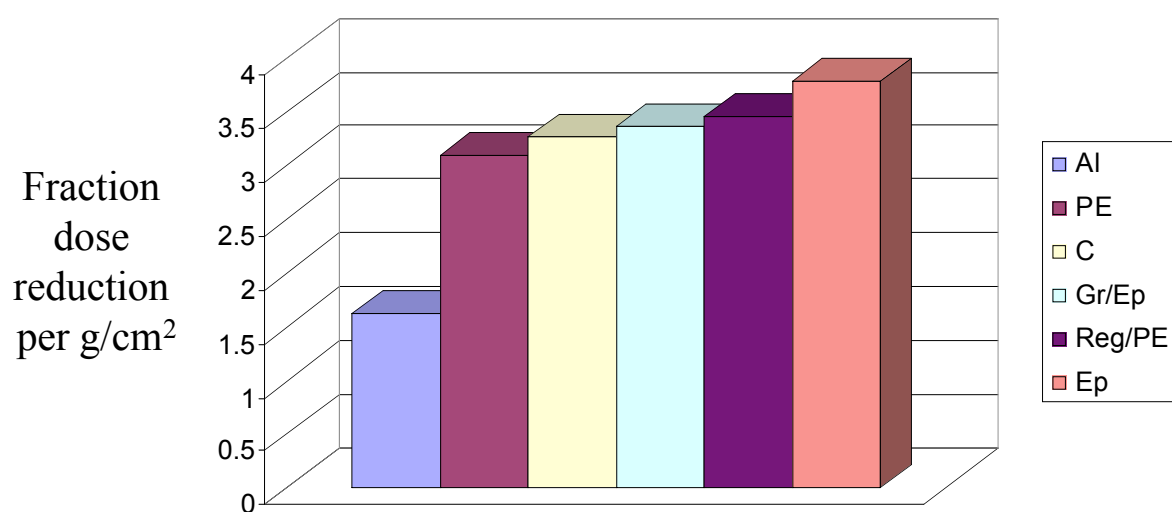
TGA 5% Mass Loss Temperature  
for Regolith/PE Microcomposites



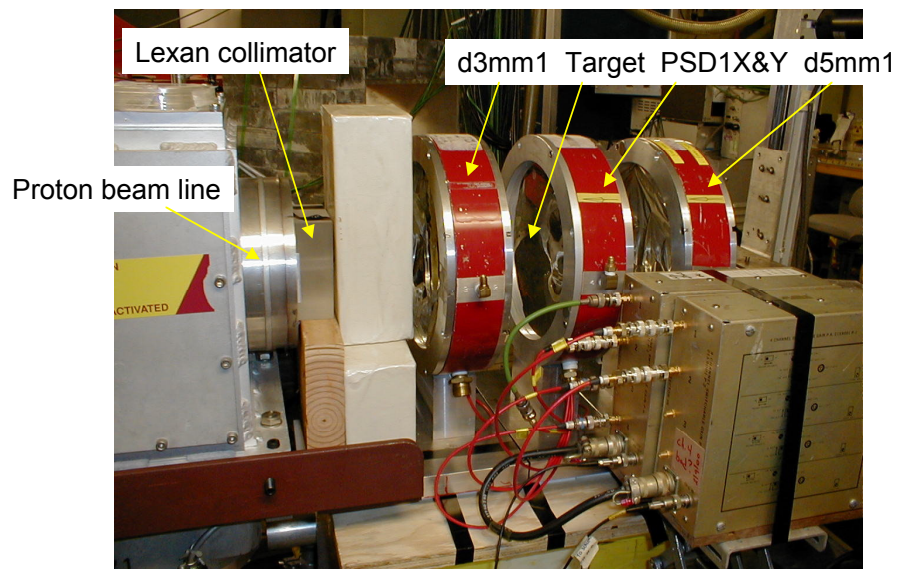
# BNL-AGS/NASA Shield Test Facility



## Experimental Radiation Shielding Effectiveness of Various Materials for 1.06 GeV Fe Ions

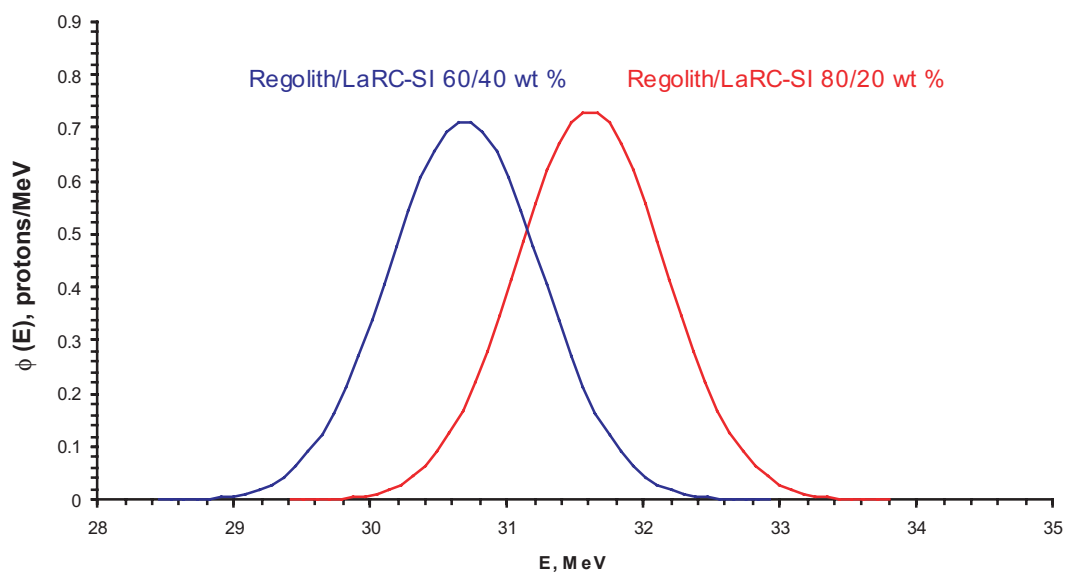


## Experimental Setup of 88" Cyclotron at LBNL



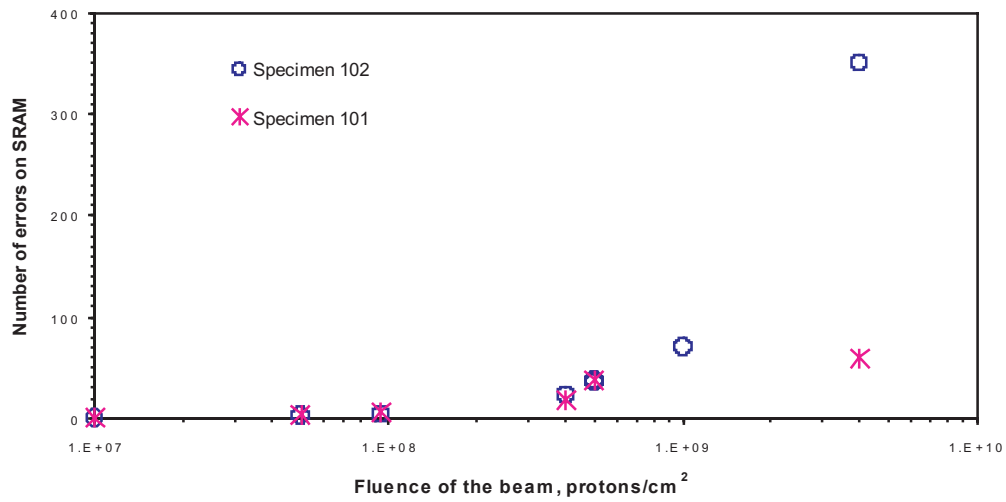
- Nearly Monoenergetic Proton Beam ( $34.5 \pm 0.266$  MeV)
- E-Spectrum without Target ( $23.68 \pm 0.46$  MeV)
- Statistics (on the order of 1-2 Million Events)

Transmitted Differential Proton Energy Spectrum  
for 55-MeV Proton Beam  
(2.01 g/cm<sup>2</sup> thick targets)





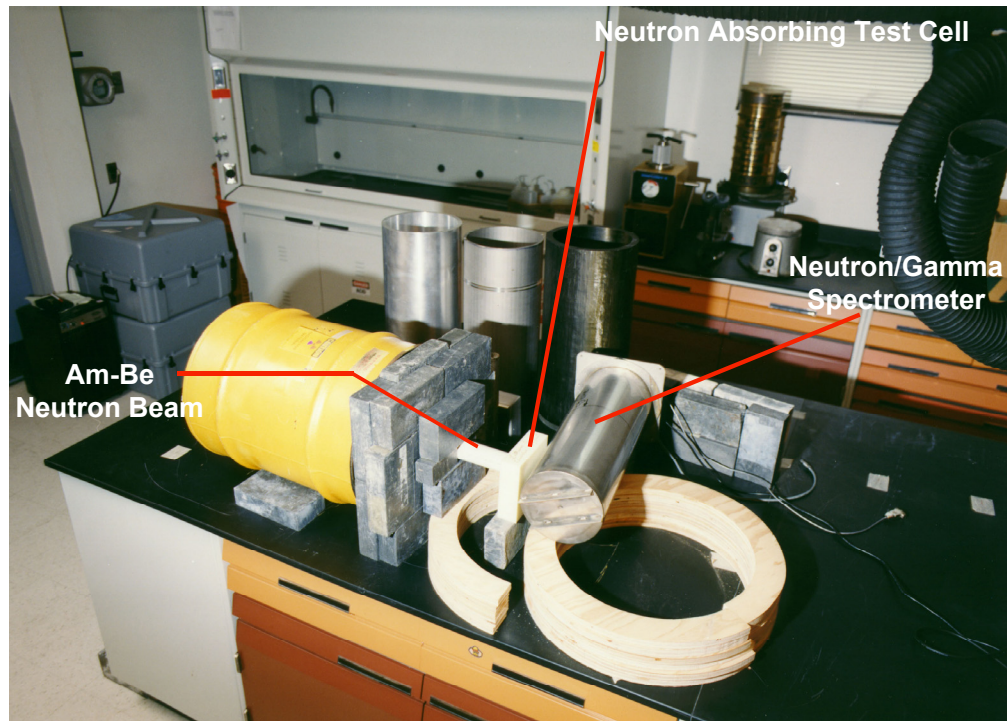
## SEU on Motorola MCM6246-5V SRAM from 55-MeV Proton Beam



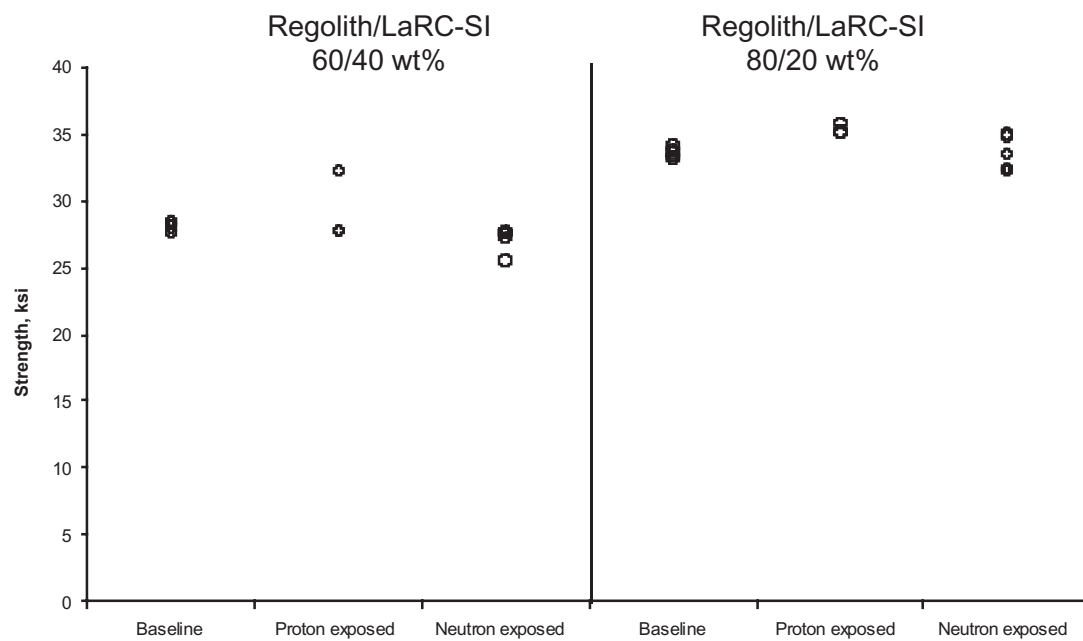
Specimen 102: 80% regolith/20% LaRC-SI

Specimen 101: 60% regolith/40% LaRC-SI

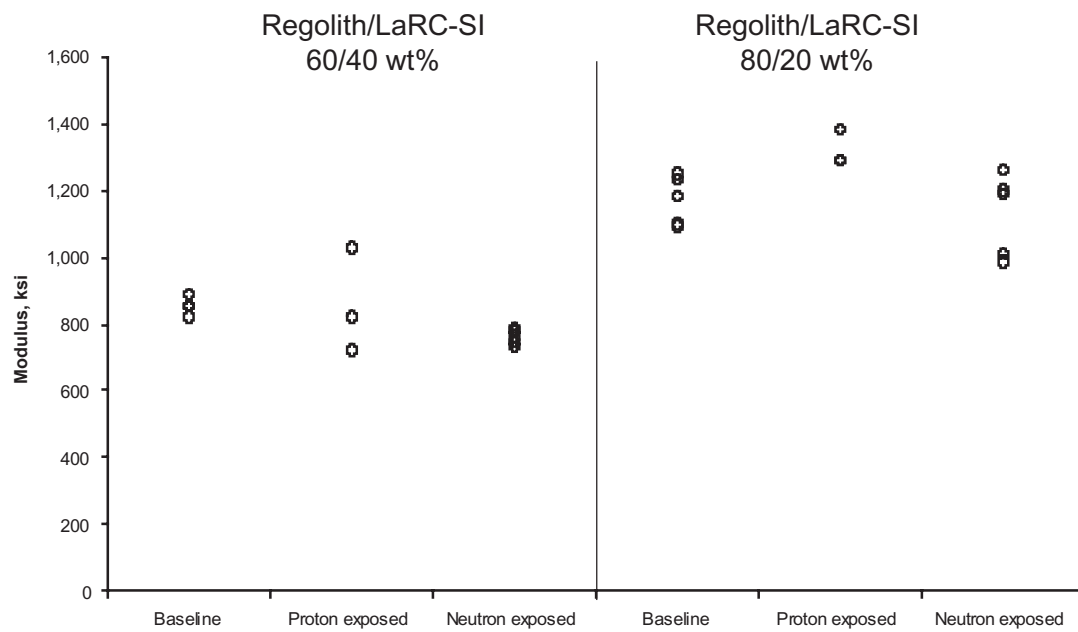
## Langley Fast Neutron Shield Test Facility



## Ultimate Compressive Strength for Regolith/LaRC-SI Microcomposites



## Compressive Modulus for Regolith/LaRC-SI Microcomposites



# Multilayered Habitat Concept

